The potential of Augmented Reality to amplify learning and achieve high performance in the flow of work

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The longevity of work skills and knowledge is constantly diminishing. This phenomenon provokes significant challenges for both employees and industries. There is a growing realization that we must all continue to 'learn to earn' (Bersin, 2015) in order to maintain employability to sustain the economic means to live life. This short conceptual paper proposes that there are increasing opportunities to learn new capabilities and practices and achieve high performance through learning in the flow of work. It explores the potential and constraints of Augmented Reality, as an emerging technology, to amplify workplace learning.

Keywords: performance support, learning in the flow of work, five moments of learning need, Augmented Reality

Introduction

> Human's ability to adapt to technological change is increasing, but it is not keeping pace with the speed of scientific & technological innovation. To overcome the resulting friction, humans can adapt by developing skills that enable faster learning and quicker iteration & experimentation.
>
> Mary Meeker, June 2019

Work and jobs as we knew them are changing rapidly. According to the World Economic Forum's (WEF, 2016) report on 'The Future of Jobs', the impact of technical and other changes is quickly reducing the shelf-life of workers' skill sets. With constant advances in automation, robotics, machine learning, globalisation and disruptive business models, the skills, behaviours and knowledge required of employees is quickly evolving and becoming more complex and multi-disciplinary. There is a growing realisation that continuous upskilling of workforce capabilities is key to the workforce agility and value. Consequently, the capabilities that determine employability are continuously changing over time.

This short conceptual paper explores the potential and constraints of Augmented Reality (AR) technologies to enable more rapid upskilling and reskilling of employees. It highlights the significance of the rapidly changing learning needs of worker-learners and their organizations and the need to learn in the flow of work. Using a number of case studies, the main focus is on the evolving potential of AR to provide the means to amplify learning in the flow of work.

The changing learning needs of employers and worker-learners

The need for people to continuously learn, unlearn, upskill and reskill has never been greater. The velocity of change means that the scope of what people need to learn to keep their knowledge and skills current for employability is ever-increasing. Equally, recruitment is expensive and so industries need their existing employees to develop in-demand capabilities and apply their learning quickly and efficiently in response to continuous change. In a study of over 600 learning and development (L & D) leaders (Jennings, Overton, & Dixon, 2016) representing 1,600 learners from 55 countries, 90% of L & D leaders expressed a strong desire to:

- Increase on-the-job productivity
- Respond faster to business change
- Improve employee engagement
- Reduce time to achieve competencies
- Improve the application of formal learning in the workplace

From a worker-learner perspective, there is also a growing realization that continuous upskilling is essential for continued employability. That is, you need to 'learn to earn' (Bersin, 2015). In turn, this awareness is positively

influencing employees' motivation for, and investment in, learning. In fact, in the same study (Jennings, Overton, & Dixon, 2016), researchers asked L & D leaders about what motivates their staff to learn. Their findings suggest that:

- 76% would like to do their job 'faster and better'
- 75% want to learn for their own personal development
- 60% would like to increase their productivity
- 47% would like to keep up-to-date with new technologies
- 42% find working towards some kind of professional certification is motivating

However, the time required for continuous upskilling and reskilling is a concern for both industry leaders and employees. The tension is that there is both too much to learn and not enough time to learn. In formal courses, much of what has been taught is not remembered when the time comes to apply new knowledge to the task at hand. In the workplace, when an employee needs to solve a problem or complete a task, unproductive time can be spent on searching Google, YouTube or the company intranet to find relevant information to solve their challenge. There is a need to think about learning more strategically about how to support workers to improve or acquire new capabilities more quickly so they can do their job 'faster and better' in the flow of work.

Learning in the flow of work

'Learning in the flow of work', 'frictionless learning', and 'performance adjacent learning' (Herbert-Maccaro, 2018) are just a few terms that encapsulate the idea of learning in the context of the work you are performing. These approaches offer employees learning on-demand, point-of-need learning and/or short bursts of learning in concert with, or adjacent to, their workflows. The concept of learning in the flow of work is at the heart of the widely known 70-20-10 performance-oriented learning model and the popular Five Moment of Need model. The model is premised on the idea that you gain 10% of your learning from formal instruction, 20% from learning from others and 70% by learning from your on-the-job experiences.

While the 70-20-10 model shines light on the role of workplace learning, it does not really help us understand how and when people learn and become competent in the tasks they need to perform and how to best support their learning and performance. Some years ago, Gottfredson and Mosher (2012) argued that 'we turn our attention to the workflow and deliver the support employees need to not only be competent at their work, but to also sustain that competency in an ever-changing environment'. They further posited that in order to provide the support needed along the way we need to understand the learner journey, from the beginner stages of learning through to that challenges that can happen when learning is applied, and learners need to perform. Gottfredson and Mosher (2012) proposed Five Moments of Learning Need which are intended to 'comprise the full spectrum of performance support needs.'

1. NEW – learning something for the first time
2. MORE – expanding the breadth and depth of what has be learnt
3. APPLY – Acting upon what has been learnt (including planning what to do, remembering what they have learnt or adapting what they have learnt to transfer to a new context)
4. SOLVE – solving new problems when they arise, or when things don't work as expected
5. CHANGE – learning a new way of doing things that may require a skill or knowledge change that alters performance and practices

The evolving affordances of AR offer one way to support workers' learning and performance needs directly into the workflow. Using AR, it is possible to embed 'new' and 'more' into the workflow in real time, and to provide performance support tools that are immediately accessible and tailored to the situation of the user.

Augmented Reality

For those unfamiliar with AR, it is differentiated by other realities, such as Virtual Reality which is completely computer generated, because AR superimposes a digital overlay on a real-world environment in real-time. That means the user can simultaneously see their own reality as well as an Augmented (digital) Reality – so they don't lose sight of the real-world context around them. According to the Augmented Reality for Enterprise Alliance, a global member-based organisation for the widespread adoption of interoperable AR-enabled enterprise systems, augmented reality includes:

> Any technology that "augments" the user's visual (and in some case auditory) perception of their environment. Typically, digital information is superimposed over a natural, existing environment. Information is tailored to the user's physical position as well as the context of the task, thereby helping the user to solve the problem and complete the task.

The main types of Augmented Reality vary in complexity. Location and Marker-based AR are simpler in terms of implementation and connection to content, whilst Markerless and Projection-based are more complex and sophisticated and offer a more seamless immersion across the real and digital environment.

1. **Location-based AR**
   Utilizes GPS, accelerometers and digital compasses available in the device used to provide information overlays relevant to the location. That is, the learner's location triggers content.
2. **Marker-based AR**
   Utilizes a camera available on a device, such as a smart phone, tablet or webcam, to scan an image called a 'marker'. The marker may be any kind of visual such as a QR code, a barcode, a photo. In marker-based AR the maker triggers the overlay of content such as video, text, and animation.
3. **Markerless AR**
   Utilizes a camera to scan the actual surrounding physical world such as a piece of equipment that requires maintenance, for example a whole car engine. Content is then mapped to the visual environment and the user may also be able to zoom in, manipulate and interact with 3D models that assist them in their decision-making and performance.
4. **Projection-based AR**
   Utilizes advanced projection technology to projects light onto a real-world object or environment to create a light-based interface that can guide users in their completion of more complex tasks.

AR Use Case Examples

Social AR to improve performance in construction and facilities maintenance
This first use case uses an Android mobile app that was designed for social augmented reality in construction, and facilities maintenance service industries (Pejoska, Reponen, Virnes & Leinonen, 2017). The catalyst for the app development was a recognition that improved communication and remote collaboration practices could assist younger workers on site who needed to tap into the knowledge of the older, more senior workers. Given the younger workers typically used smart phones for communication, a mobile app was developed in an effort to change communication and collaboration practices for point of need, informal learning in the flow of work The Social Augmented Reality app (SoAR) uses video calling functionality to create a video stream of what the user was seeing (using the back camera view) as well as audio to discuss the work task context.

The ability to have a shared view of the objects and surrounds was critical to the industry context as 'it creates a common ground for collaboration, serves as a basis for situation mapping, supports the identification of issues and makes assumptions and beliefs visible' (Pejoska, Reponen, Virnes & Leinonen, 2017, p.12). Additionally, it provides situational awareness which provides the foundations for a thorough understanding of the task or problem that may be difficult to explain verbally. For collaborative purposes, there is considerable value in being able to point to objects and contextual information in the shared view. Using the app, the video stream could be paused to a static view whereby users could use their finger to create pointers and circles – thereby focusing their discussion. Three field studies were conducted in Finland and Germany concluded that the app was both usable and useful. Apprentices, in particular, could identify both efficiency and productivity gains. The directness of being able to call the right person at the right time and resolve the issue with immediacy and confidence was helpful. The major challenges were around harsh weather conditions, noise, screen visibility, and connectivity on-site.

Hololens™ for elevator maintenance
This second use case relates to improving point of need support in the workflow of elevator service engineers. The global engineering company Thyssenkrupp, recognised that over 1 billion people ride elevators every day. They provided support to service engineers using Microsoft Hololens AR technologies in order to improve the efficiency and effectiveness of their practices across the globe. When an elevator service engineer is dispatched to a job they put on their Hololens and see a 3D picture of the elevator they are going to work on and relevant information about the elevator. They can zoom into different parts of the elevator and within the digital AR layer, different training opportunities are available. These include video tutorials, checklists as well as historical notes on previous services on that particular elevator and safety alerts. Together, this information and knowledge can save time and prepare the technician, as never before, ahead of going to the job site.

At the elevator service site, the technician is handsfree while using Hololens to perform routine tests and examine parts to identify issues. For further support and expertise, technicians can trigger a remote call, using Microsoft Remote Assist. This means they can collaborate with a subject matter expert (who can see what the technician is seeing) to decide on the best course of action. Tests showed a huge potential to increase productivity as a result of this approach. Impressively, the time saved in conducting the maintenance was reduced from 1-2 hours to 20 minutes.

Light Guide and TrainAR™
Light Guide Systems offer projection-based AR to simplify complex manual tasks related to assembly or inspection in industries such as car and pacemaker assembly. Simplified text and other visual information is projected in front of the employee to support their performance as they complete tasks. In this way, employees can also learn to operate safely and collaboratively with robots in factory assembly plants. Chrysler reported an 80% improvement in quality and 40% improvement in productivity in their car manufacturing.

Using the Light Guide TrainAR™ System, a digital overlay can be projected onto any type of part or assembly providing step-by-step work instructions and visual and audio guidance. This is a customizable training environment with preloaded templates for fast and simple lessons. Employees can then take short tests to confirm understanding and learning progression before performing the tasks on the factory floor. This approach can significantly shorten the time lapse between training and application.

The potential of Augmented Reality

Studies reviewed for this paper, suggest AR has the following potential to amplify learning and achieve high performance in the flow of work in the following ways:

- *Reduce time to achieve tasks:* Recent reviews of industry and academic studies (e.g., Farrell, 2018, Akçayır & Akçayır, 2017), found strong indications that enabling AR in the workflow can mean employees achieve tasks more efficiently. For example, a collaboration between Boeing and Iowa State University found a 30% reduction in time to complete tasks as a result of AR training compared to groups who received traditional documentation or documentation on a tablet device nearby the assembly line (Richardson et al., 2014).
- *Reduce time to achieve competencies:* Many studies reviewed mentioned decreased time to achieve competence as an important affordance (e.g., Farrell, 2018, Lotring, 2005).
- *Enhance problem-solving and decision-making:* Using the affordances of AR can provide employee the most up-to-date information to make decisions and complete tasks in ways that are most optimal and efficient. Dunleavy, Dede and Mitchell (2009) identified the most important affordance of AR for learning is its 'unique ability to create immersive hybrid learning environments that combine digital and physical objects, thereby facilitating the development of processing skills such as critical thinking, problem solving, and communicating' (p.20).
- *Improve memory and understanding and reduce cognitive load:* Studies have found some evidence of improved memory recall when using AR systems to support performance (Tang, Owen, Biocca and Mou, 2003). Another benefit is improved understanding, particularly of complex concepts, when essential information is attached to the user's physical world view (Lotring, 2005, Squires, 2017). Furthermore, it has been hypothesized that with support from AR, cognitive load may be reduced when performing complex tasks (Squires, 2017).
- *Reduce error rates & improve health and safety:* Due to the nature of just-in-time performance support, a decrease in error rates and improvements in quality, and health and safety in equipment use have also been reported. Studies at Colombia University (Henderson & Feiner, 2011) found that participants using AR demonstrated more accuracy in task completion over 53% of the time.
- *Increase employee engagement and motivation:* Participants engaging in AR training have also reported experiencing AR training as more intuitive, motivating and engaging than other forms of training – although there may be a novelty affect influencing participant perceptions (Akçayır & Akçayır, 2017).

Constraints of Augmented Reality

Gartner research (Pettey, 2018) suggests that immersive technologies like AR will not reach maturity for another 5-10 years. There are still a range of constraints that challenge wide-scale take up, such as:

- *Interoperability:* According to the IEEE Computer Society (2016), 'the lack of AR interoperability and, consequently, AR content, stands in the way of rolling out such training to an emerging market in the numbers required' (p.96).

- *Design:* As Augmented Reality is still an emerging technology and a complex solution, a major constraint is in designing and implementing training solutions (Drljevic, 2017; Farrell, 2018). This includes considerations around whether AR will require a live internet connection to receive data and whether internet connectivity is reliable at the worksite.
- *Usability:* Usability is a key design consideration as AR solutions can be difficult or clunky to use in employees work environments (Akçayır & Akçayır, 2017). According to Dickson (2018), AR headsets and glasses also have some limitations. Some headsets are bulky and heavy which makes them uncomfortable to wear over extended periods of time. Motion sickness and headaches have also been reported. A limited field of view can also reduce the user's sense of immersion. Climatic events can affect usability in some work environments (Pejoska, Reponen, Virnes & Leinonen, 2017).
- *Adoption:* Resistance to change, fear of threat to jobs and issues associated with digital literacies of the target audience are key implementation considerations (Akçayır & Akçayır, 2017)
- *Interaction:* The user interaction afforded by glasses, headsets and other AR tools are still immature. Some have touchpads on the side of the frame that utilise swipes and taps to change and activate the menu while others have handheld controllers. Voice commands can be of limited use in noisy environments.
- *Safety:* The physical environment of the job at hand needs to be assessed as to whether it can safely support the use of AR (Farrell, 2018). Assessment needs to consider safety considerations while learners use AR. For example, could workers be more prone to trip hazards while looking at their devices in the work environment? Strategies, policies and procedures to manage safety are critical.
- *Governance frameworks, policies and security:* According to ISACA (2016), AR virtual graffiti attacks and the collection of information from social media and other sites pose a reputational risk. Privacy is yet another concern. Companies need strategies to proactively manage these risks and to update their governance frameworks and policies to incorporate AR as part of their business.

Final thoughts

AR, as an evolving technology, has strong potential to amplify workers' learning and performance needs in their flow of work. In relation to the 70-20-10 model, AR can offer the ability to learn more efficiently and effectively on-the-job in the context of real work tasks and to connect with other SME's across the company for mentoring, coaching, observation and feedback.

Thinking back to Gottfredson and Mosher (2012) Five Moments of Learning Need and the potential of AR:

1. NEW – tutorial content can be designed help workers learn something new. Because information is visually layered over the physical environment it may be easier, and quicker to understand and learning can be delivered in shorter focused chunks (Farrell, 2018)
2. MORE – because AR can deliver just-in-time performance support, learning is expanded in the context of the task at hand. Virtual coaches, mentors and SME's can contribute to the breadth and depth of learning experience. Content can be pushed in terms of prior achievement and employee readiness.
3. APPLY – using AR at point of need provides the performance support to help refresh prior knowledge, use real time data and information and tap into expertise that can support performance as knowledge is applied.
4. SOLVE – Information and coaching provided through the digital layer can help solve unexpected problems as they arise
5. CHANGE – New information and practices can be integrated into AR to re-skill or upskill workers as knowledge and practices change.

Certainly, in terms of reskilling, upskilling and maintaining employability in times of such rapid change, there is emerging potential to help worker-learners to maintain and amplify their capabilities in the flow of work.

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